

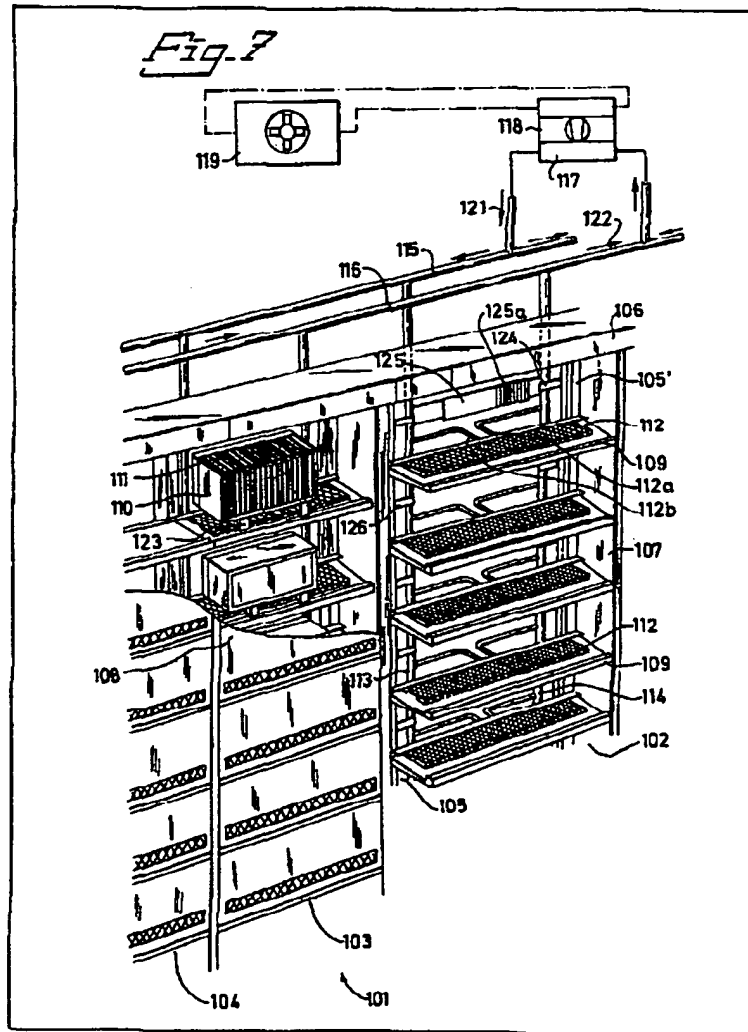
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(54) Apparatus for cooling telecommunications equipment in a rack

(57) A rack contains a number of shelves (109) arranged on top of each other, which carry, among other things, board magazines (110) with printed circuit boards (111). An apparatus for cooling the printed circuit boards is based on the principle that one or more shelves in the rack are integrated each with its own heat exchanger, which is equipped with

cooling flanges and at least one tubular coil. The heat exchanger is connected to a cooler (117) for a coolant. The heat exchanger (112) covers the greater part of the horizontal plane of the shelf. Extensive heat-conducting contact surfaces are provided between the board magazines and the body of the shelf and between the latter and the heat exchangers. Heat removal is also provided for by natural convection at the hot and cold surfaces and by radiation.



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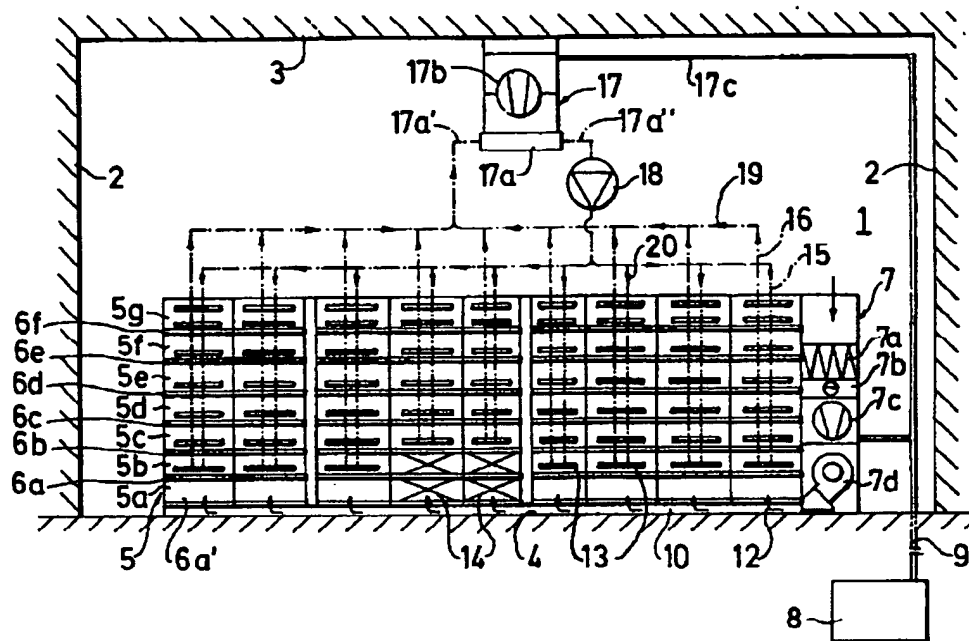
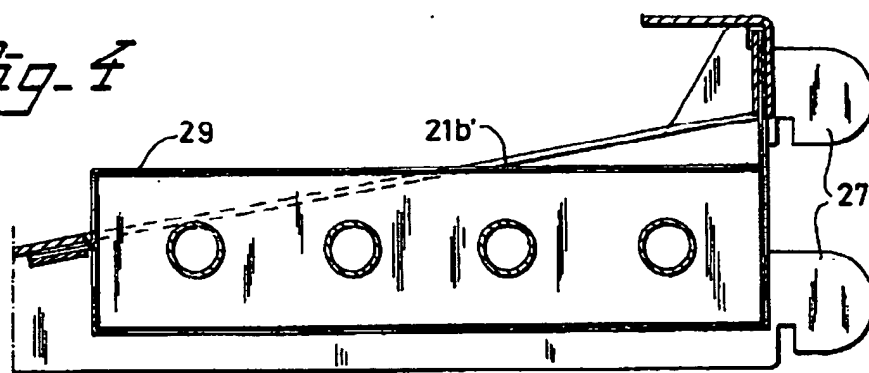
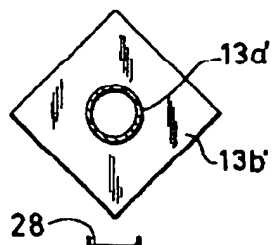
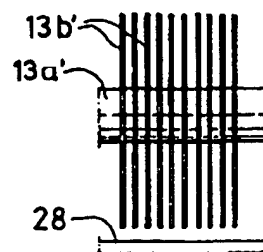
*Fig. 1**Fig. 4**Fig. 5**Fig. 6*

Fig. 2

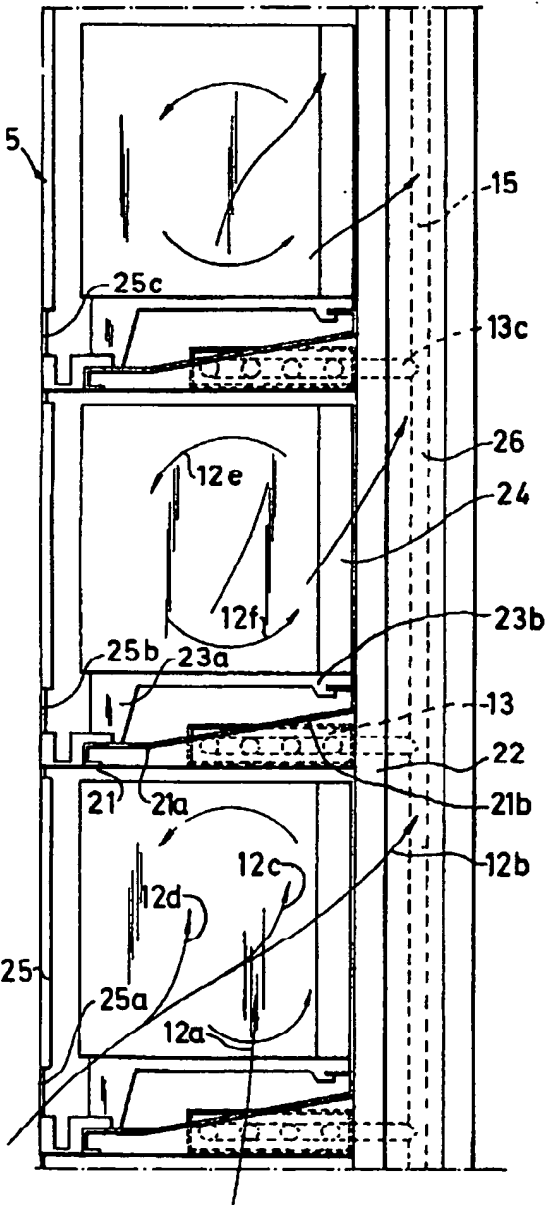


Fig. 3

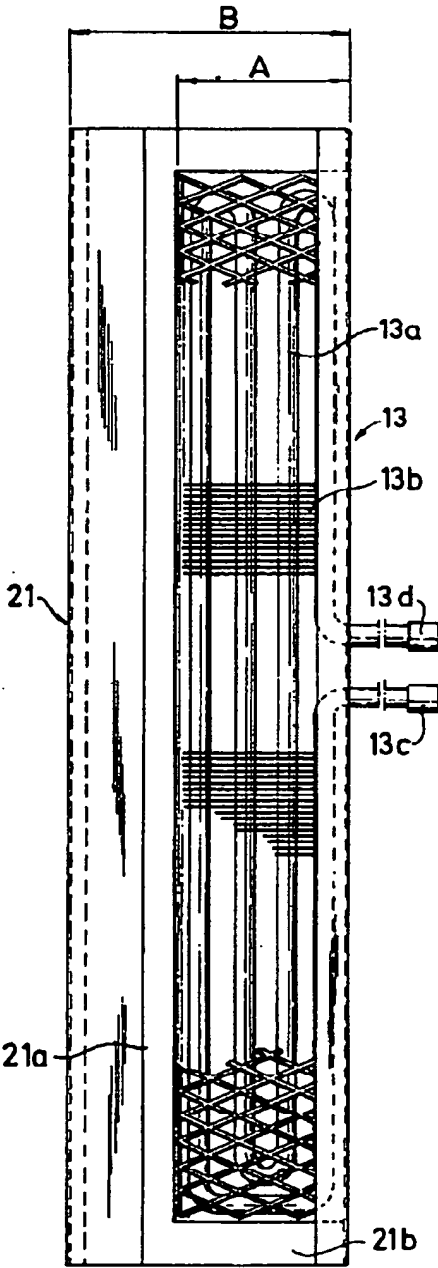
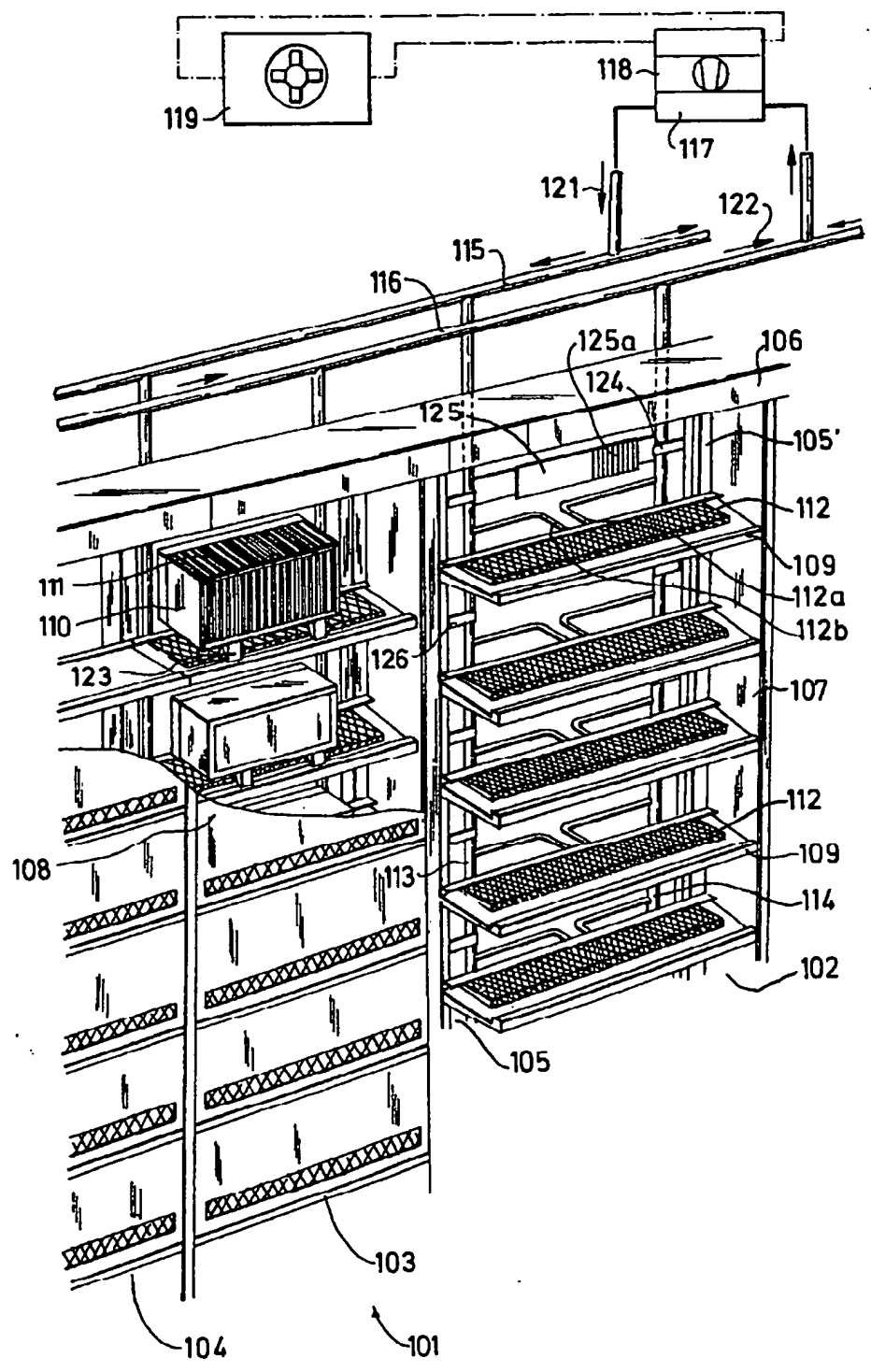


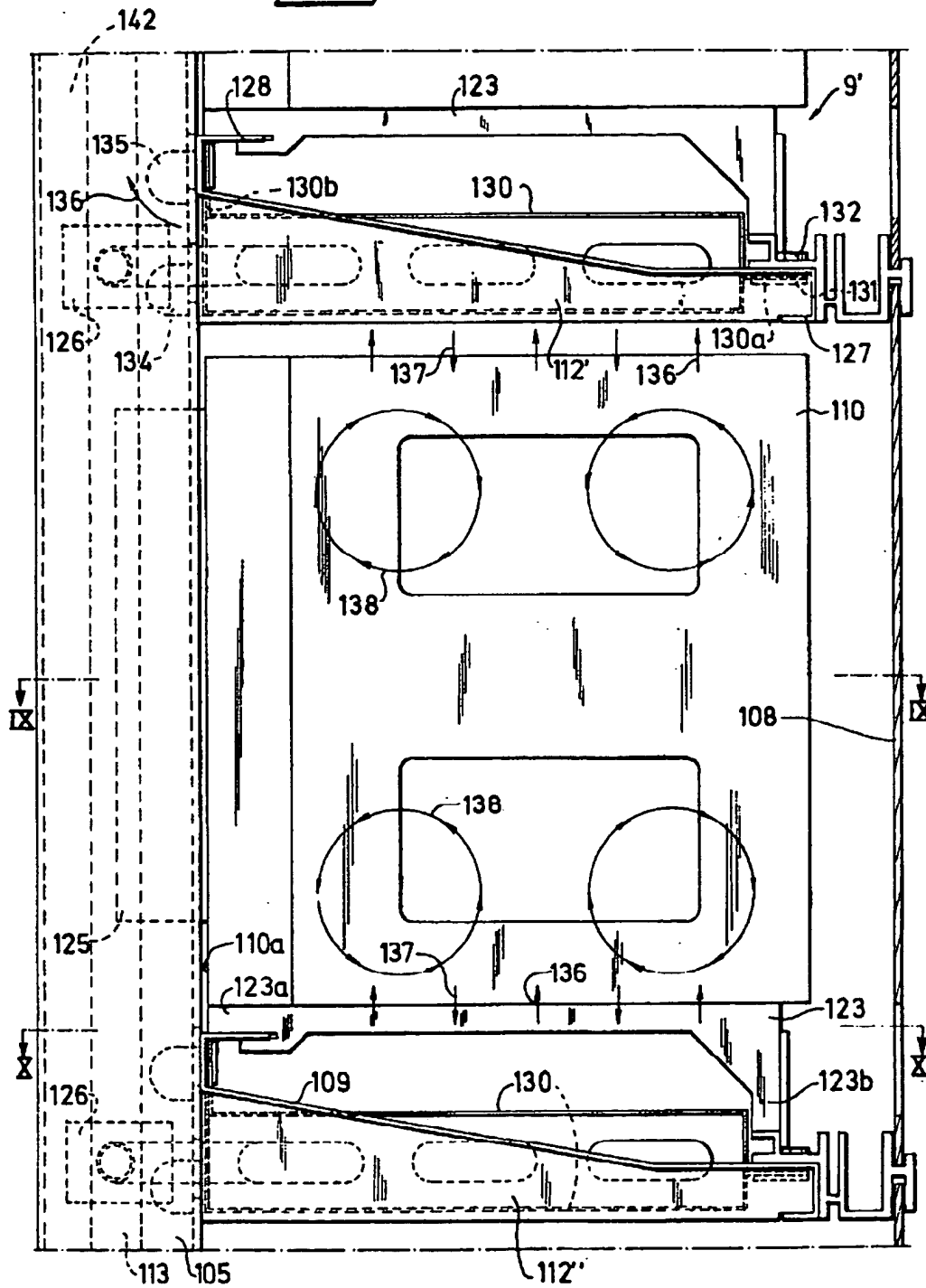
Fig. 7

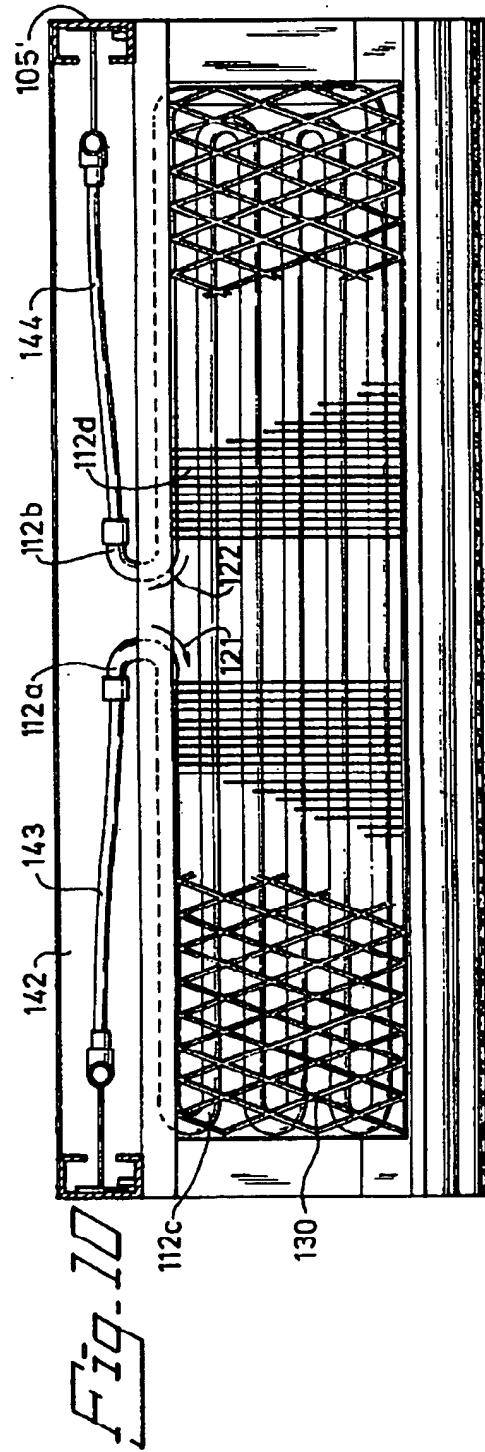
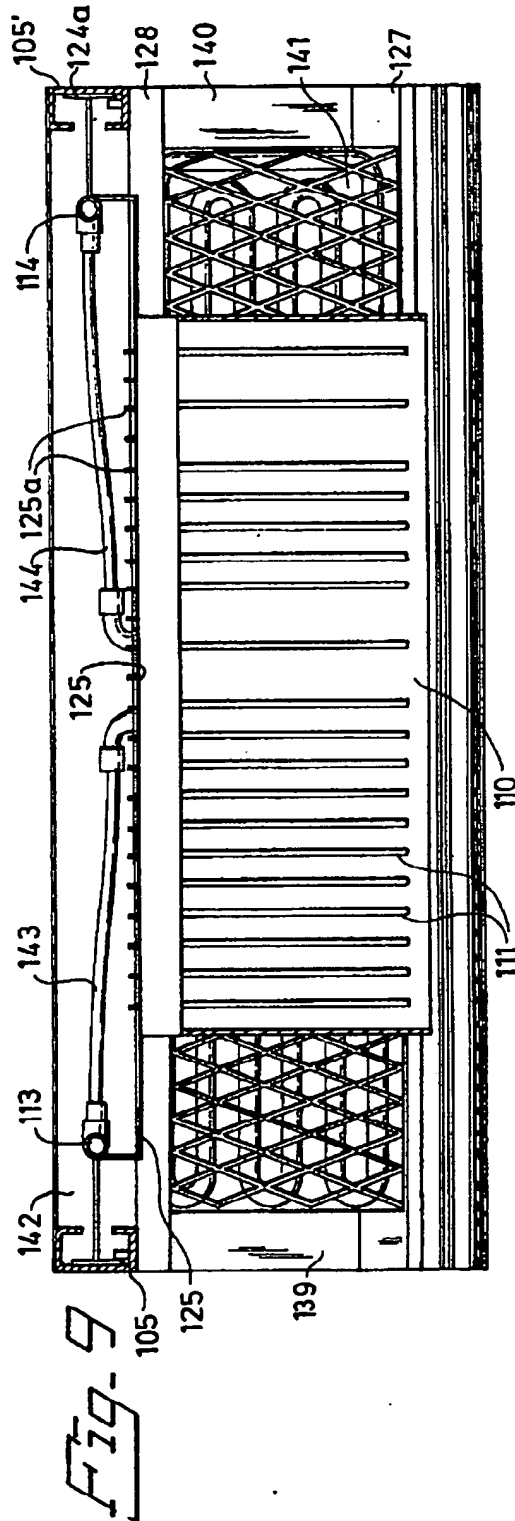


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Fig. 8





**SPECIFICATION**  
**Apparatus for cooling telecommunications**  
**equipment in a rack**

**Technical Field**

- 5 The present invention relates to an apparatus  
for cooling telecommunications equipment  
mounted in a rack with a number of shelves  
located on top of each other, which equipment  
consists of component-carrying printed circuit  
10 boards housed in board magazines, which are in  
turn applied to the aforesaid shelves. The term  
"telecommunications equipment" is also used  
here to denote general electronic equipment  
15 mounted in racks that is used outside of the field  
of telecommunications as well.

**Description of the Prior Art**

- A means of achieving cooling of  
telecommunications equipment mounted in one or  
more racks, for example at a telephone exchange,  
20 is already known. Such a rack may contain eight  
shelves, and two such racks generally form a  
so-called "double rack". The board magazines that  
are applied to the aforesaid shelves are thereby  
arranged to store, on end, a number of boards with  
25 printed circuits and/or components, such as  
relays, condensers, resistors, inductances etc. A  
magazine may contain 50 such boards, which  
means that a double rack may contain some  
1 000 boards.

- 30 Heretofore, it has been proposed to cool such  
telecommunications equipment solely with the aid  
of so-called "open cooling systems", which  
comprise a compressed air source, for example in  
the form of a fan, whose initiated air stream is  
35 conducted from an air duct at the lower parts of  
the rack or racks and upwards in each rack so that  
it can pass the boards placed on end in the board  
magazines and be discharged at the top of the  
rack or racks out into the premises. The air is  
40 recirculated to a cooling unit, where the air can be  
cooled and dried before it is once again  
recirculated to the racks, and so on.

**Description of the Present Invention**  
**Technical Problem**

- 45 A fervent desire exists to be able to increase the  
density of components on each printed circuit  
board so that a larger number of components can  
be accommodated within the same volume. This  
results in heat output from the boards in the racks  
50 that is difficult to handle with present-day cooling  
equipment for telecommunication racks. The heat  
outputs in question can be up to 10 Watts per  
board or more.

- In light of the above, new ways must be chosen  
65 to obtain heat removal from the board magazines  
so that maximum component temperatures can be  
kept to a reasonable level, a must in order to  
ensure good function and long life of the  
components in question.

**Solution**

The main purpose of the present invention is to

- create an apparatus that solves the problem of  
efficient removal of the heat emitted by the  
printed circuit board components. What can  
65 thereby be said to be essentially characteristic for  
the new apparatus is that one or more shelves are  
integrated each with its own heat exchanger  
incorporating cooling flanges and at least one  
tubular coil, which is connected via the heat  
70 exchanger to a cooler for a coolant in the tubular  
coil; that the heat exchanger, viewed in the  
horizontal plane of the shelf, extends along the  
greater part of the shelf; that extensive heat-  
conducting metallic contact surfaces are arranged  
75 between the board magazines and the shelf and  
between the shelf and the heat exchanger; and  
that the aforesaid heat exchanger and cooler are  
arranged so that they are able to remove the  
aforementioned emitted heat even at a high  
80 packing density of the aforesaid telecommunications  
equipment in the rack and a high heat output from  
the said equipment. Inter alia with the aid of heat  
conduction via the aforesaid extensive contact  
surfaces.

- 85 In further elaborations of the invention concept,  
specifications are recommended for the more  
detailed construction of the different parts of the  
apparatus. Thus, in one proposed embodiment the  
majority of the shelves in the rack are to be  
90 equipped each with its own heat exchanger, in  
addition to which the heat exchangers' tubular  
coils are interconnected and preferably connected  
to one and the same cooler. The cooler with  
appurtenant compressor may thereby take the  
95 form of a tubular evaporator or fluid cooler that is  
incorporated in a cooling circuit together with,  
inter alia, a condenser (water recooling). The latter,  
at least, should be located outside of the premises  
in which the rack or racks are set up.

- 100 The heat exchanger or heat exchangers and the  
appurtenant cooling equipment are thereby  
arranged and operated in such a manner that the  
surface temperatures of the components on the  
boards assume values that are acceptable in the  
105 context, for example max. about 75°C. The heat  
exchangers and the cooling equipment should  
preferably be arranged in such a manner that most  
of the components on each board assume  
relatively low temperatures, e.g. below 65°C. In  
principle, it is possible to arrange and operate the  
110 equipment in such a manner that lower  
component temperatures are achieved. In order to  
effect the above, each heat exchanger should be  
provided with a relatively large effective cooling  
surface area, in one embodiment preferably in  
115 excess of about 1.5 m<sup>2</sup>. As an example, it can be  
mentioned that the cooling surface area can be  
chosen within the range 1.5—4 m<sup>2</sup>. Each heat  
exchanger shall be provided with a relatively large  
cooling capacity, e.g. in excess of 150 Watts, and  
120 in this context it can be mentioned that the  
invention makes it possible to achieve very high  
cooling capacities from each heat exchanger, for  
example 500 Watts or more.

- 125 The integration between each heat exchanger  
and its associated shaft is further designed so that

absorbing heat from the racks. As shown by arrows 12c and 12f, air eddies are also created in the rack. An example of the velocity of the fluid in the closed piping system is 0.2—0.4 m/s. The piping system and the tubular coils in the heat exchangers consist of copper tubing with an inside diameter of about 10 mm. The velocity of the upward air streams in the racks is 1—5 m/s. The temperature on the premises can be +23—24°C.

Figure 2 shows three compartments in a rack 5. For each shelf, a side piece 21 is shown, which is fitted at the rear of the rack with hook devices (not shown) by means of which the shelf can be attached to the rack posts 22 on either side of the shelf. The aforesaid rack posts are provided with slots into which the aforesaid hook devices can be inserted and secured in known manner. At its inner and outer ends, the shelf bears the bracket that supports the lower parts 23a and 23b of a board magazine that carries the boards standing on end. Figure 2 shows a board, indicated by 24. The boards are mounted in the magazine with intervening spaces, and each board carries components (not shown) and printed wiring on one or both sides. Since the constructions of the shelf, the board magazines and the boards are presumed to be known, they will not be described in any greater detail here. It can however be stated that the shelf consists of, besides the aforesaid side pieces 21, a load-bearing surface which, in the view shown in figure 2, is composed of two flat sections 21a and 21b which meet each other at an angle. For the future, a shelf design is being discussed with a single surface that runs essentially perpendicular to the vertical direction of the rack. This surface can be assumed to coincide with the left-hand flat portion 21a of the shelf's load-bearing surface. The invention also applies for other shelf planes, however, for example planes that coincide essentially with the section 21b. The upward air stream in the rack is divided as shown in figure 2 into a number of substreams 12a, 12b and 12c. The rack can be equipped with a section 25, provided with a number of slots for air that flows upward from the lower parts of the rack and via the slots into the rack in question. In the embodiment shown, a slot section 25a, 25b, 25c is provided at each shelf. At the lowest shelf, the air flows in from the cooling duct via the slots into the adjoining section and then upward between the aforesaid boards. Air also enters at the overlying shelves via their slot sections. The air flowing upward in the rack passes the shelves with their heat exchangers 13 and continues up via the lower parts of the board magazines and up between the boards to the overlying parts, and so on. Except for the aforesaid rack posts 22, the rack is completely open in back, and a chimney duct 26 is provided at the rear of the rack, in which some of the air can escape on its passage upward through the rack. The upward and backward sweeping air stream created in this fashion provides good cooling, especially at the rear parts of the rack, which are the most critical from the viewpoint of cooling.

Figure 3 shows the shelf 21 in a horizontal view from above. As is evident from the figure, the flat or sloping portion 21a, 21b contains the cavity for the heat exchanger, which is of the type that incorporates a tubular coil 13a with attached cooling flanges 13b. The heat exchanger has a large extent in the plane shown in figure 3 and occupies a large part of the plane of the shelf in question. As an example of what is meant by "a large part" in this case, it can be mentioned that the heat exchanger shall occupy 80—90% of the plane of the shelf in question. The heat exchanger exhibits a depth A equal to about 2/3 of the depth B of the shelf. The heat exchanger extends from the rear parts of the rack (the beams 22) towards the front of the rack. Owing to its relatively far retracted position in the rack, the heat exchanger provides an effective cooling function at the same time as the shelf retains a reliable load-bearing function. The heat exchanger can be attached to the shelf and/or the rack. The points of attachment have extensive contact surfaces that ensure good heat conduction from the warmer parts of the heat exchanger to the colder surfaces on the shelf and/or the rack. The tubular coil 13a is fitted with an inlet connection 13c and an outlet connection 13d which, in accordance with the above, shall be connected to the first and second pipelines. The aforesaid first and second pipelines can be run in the aforesaid chimney duct 26. Parts of the first pipeline's 15 run in the aforementioned duct 26 have been indicated in figure 2. The tubes in the aforesaid tube coil in the heat exchanger extend primarily in the transverse direction of the shelf along most of the aforesaid transverse direction. In the embodiment shown, the aforesaid tubular coils extend along 90—95% of the shelf's transverse direction. The cooling flanges on the heat exchanger can be square, circular or of another shape.

Figures 5—6 are intended to illustrate an alternative embodiment of the heat exchanger and its application to the shelf, whose sloping portion 21b' is indicated in figure 4. In this case, the hook devices 27 on the shelf, by means of which the shelf is attachable to the rack posts 22, are also shown. The heat exchanger's cooling flanges are of square shape in this case and are rotated 45° around their longitudinal axis in relation to the embodiment according to figure 4. In addition, the edges of the cooling flanges are upset or bent in order to provide drop collectors, and a drip tray 28 is provided under the heat exchanger. This embodiment may be appropriate when water can be expected to condense on the heat exchanger surfaces during the cooling process. This may occur when the air on the premises is relatively humid, for example because the outdoor humidity is in itself high and corridors and other passageways have stood or are standing open into the premises. Condensate may also form on the surfaces when high cooling capacities are desired from the cooling apparatus. Any moisture on the outside of the cooling flanges can run down along the edges of the cooling



flanges to the lowermost corner, under which the drip tray 28 is arranged. The drip tray can lead to one or more containers (not shown).

- The heat exchanger is also provided with a  
 5 protective grille or screen 29 so that piping can be run within the rack regardless of the aforesaid heat exchangers. The grille or screen is thereby designed so that heat is conducted between the heat exchanger and the screen or grille, from  
 10 which the heat can be conducted to the shelf and/or the rack. The contact surfaces between the grille/screen and the heat exchanger shall thereby be made relatively large in order to facilitate such heat conduction. The heat exchanger is made with  
 15 an effective cooling surface of up to 2.0 m<sup>2</sup> or more.

The apparatus described above can also be employed to advantage in premises that have an air treatment unit separate from the apparatus.

- 20 intended to bring about hygienically acceptable air conditions on the premises and, in some cases, to humidify and/or dehumidify the air on the premises.

- The shelf cooling function can, however, also  
 25 function completely separately or essentially separately as per the following. Parts of a rack row at a telecommunications exchange are indicated by 101 in figure 7. The rack construction is of known type and has been supplemented with a  
 30 cooling apparatus according to the invention. The rack row contains a number of racks 102, 103, 104 etc. and may form single or double racks. In addition to its frame with load-bearing beams 105, 106 and end and front sheets 107, 108,  
 35 each rack is provided with a number of shelves 109, arranged on top of each other, whose number in the case in question is eight. Telecommunications equipment is arranged on the shelves. The aforesaid telecommunications  
 40 equipment can thereby consist of circuit boards 111 arranged on end in board magazines 110 in known manner. Most of the shelves in a rack may carry such board magazines, while one or more shelves may carry other types of equipment, such  
 45 as transformers, power supply components etc.

- Most of the shelves in each rack shall preferably be integrated each with its own heat exchanger 112. In the case in question, all shelves in the rack 102 are equipped with such a heat exchanger.  
 50 Each shelf with appurtenant heat exchanger is thereby integrated in such a manner that the load-bearing capacity of the shelf is not unduly affected. Each heat exchanger is equipped with one or more tubular coils. In the case in question,  
 55 each heat exchanger has been equipped with one tubular coil, whose inlets and outlets are designated 112a and 112b in figure 7. The aforesaid tubular coils are connected to lines 113 and 114, to which the corresponding inlets and  
 60 outlets on the tubular coils in the other heat exchangers are also connected in such a manner that a common or continuous piping system is obtained.

- The aforesaid piping system thereby comprises  
 65 vertical first lines 113 and 114, which in turn are

- connected to horizontal second lines 115 and 116. The vertical lines link the heat exchangers within the same group together, while the horizontal lines connect the heat exchangers in the  
 70 different racks. A coolant, which consists in the present case of chlorofluorocarbon in liquid form, circulates in the aforesaid tubular coils and lines 113, 114 and 115, 116. Naturally, other coolants may also be used for this purpose. The lines 115  
 75 and 116 are also connected to a fluid cooler 117, which is included in the refrigeration equipment employed, together with a compressor 118 and a condenser 119. The cooler 117 with compressor 118 may take the form of a tubular evaporator or  
 80 a fluid cooler. The condenser (or water recooler) should preferably be located outside of the premises 120 in which the rack or racks in question are set up. The aforesaid refrigeration equipment is of the kind that is available on the  
 85 general market, and an example of such equipment is Stal-VMR (series 100), which is supplied by Stal Refrigeration AB, Sweden. The refrigeration equipment does not include circulation devices for the coolant (not shown  
 90 here), and the directions of circulation are indicated by arrows 121 and 122, whereby direction 121 is the outgoing direction from the fluid cooler 117 and 122 is the incoming  
 95 direction. The flow velocity of the coolant is dependent upon the capacity with which the heat exchangers are to operate in the racks. 0.2—1.5 m/s is a typical velocity of the coolant. The piping system and the tubular coils in the heat  
 100 exchangers consist of tubing of e.g. copper with an inside diameter of about 10 mm. The aforesaid coils and piping system are arranged in such a manner that the throughput rate in the different heat exchangers is roughly the same.

- The aforesaid board magazines, which will be  
 105 described in greater detail below, are applied to their respective shelves via brackets or cantilever supports 123, whose detailed design is also described below. Special arrangements have been made in order to achieve extensive contact  
 110 surfaces between different parts of the rack. Thus, there are extensive metallic contact surfaces at each shelf between the rack post 105' and the outgoing coolant line 113. These metallic contact  
 115 surfaces are situated on a metal plate or a metal band or similar device which is attached both to the aforesaid post 105' and the aforesaid line 113. A metal plate or a metal band 125 is also  
 120 arranged at each shelf between the two lines 113 and 114 for the coolant. The device 125 is equipped with flanges 125a. The device 125 is further arranged so that it makes contact with the back surfaces of the board magazine when the board magazine with boards is placed on the shelf  
 125 in question. A device 126 corresponding to device 124 is connected between the post 105 and the line 113 at each shelf.

- Figure 8 shows two shelves 110' and 110'' placed on top of each other in a rack according to figure 1, each shelf with its own heat exchanger  
 130 112' and 112'', respectively. Each shelf

embodiment of a rack utilizing the apparatus, in which another embodiment the shelf cooler provides the cooling function essentially autonomously, i.e. without the aid of e.g. the row cooler in figures 1—2.

Figure 8 shows, in a side view, shelves in a rack according to fig. 7 with appurtenant board magazines for printed circuit boards.

Figure 9 shows, in a horizontal section, the design of the board magazines, the shelf and the rack according to fig. 8 and

Figure 10 shows, in a horizontal section, the extent of the heat exchanger in the shelf according to Fig. 8.

#### 15 Description of the Preferred Embodiment

Figures 1—8 illustrate an embodiment where the individual cooling function in the rack shelves has been combined with a row cooling function common to all racks. In figure 1, the premises or equivalent room are indicated by 1. The premises are bounded in this case by walls 2, a ceiling 3 and the floor 4. A number of racks 5 of known type with telecommunications equipment are set up on the premises. The racks 5 shown are arranged in 25 rows and the premises may contain one or more such rows of racks. Each rack consists of a number of compartments arranged on top of one another, designated in the figure by 5a, 5b ... 5g. The compartments are bounded by shelves, which are indicated by 6a', 6a, 6b ... 6f. The shelves are designed to support various telecommunication units plus magazines with boards with printed wiring and various components (condensers, relays, resistors etc.). By "shelf" is meant here cantilevers and the like. The aforesaid boards are arranged on end in the magazines.

At the end of each row is a refrigeration module 7 that operates by means of, for example, direct expansion and is of known type. The refrigeration module in question here is sold on the market by Fläkt AB and carries the code designation KDAX. The refrigeration module comprises a filter 7a, a cooling coil 7b, compressors 7c and a fan 7d. The compressors are connected to a condenser 8 or water cooler located outside of the premises, and the refrigerant line is indicated by 9. One or more ducts 10 pass under the racks.

The air discharged by the fan 7d is blown into the aforesaid ducts and distributed in known manner between the racks, creating upward-directed and preferably dry air streams, indicated in the figure by 12.

Heat exchangers, described in greater detail below, are installed in the different shelves in the different racks. In the embodiment illustrated, most of the aforesaid shelves are equipped with a heat exchanger 13, and the new apparatus functions more effectively the more shelves are equipped with heat exchangers. 60—100% of the shelves should preferably be equipped with heat exchangers. In the middle racks shown in the figure, units 14 (not specified in any greater detail here) are installed in the lower parts. These compartments are not equipped with heat

exchangers. The same applies to all bottom compartments 6a' in the various racks. Instead, the top compartment is equipped with two heat exchangers, one of which is mounted in the ceiling of the compartment, where it provides good cooling capacity, since the air is hottest at the top of the rack. The aforesaid heat exchangers are primarily installed in compartments or shelves that are intended to carry magazines of known type for boards with printed wiring and various types of components (relays, condensers, resistors etc.). In the case of the invention, however, most of the shelves in the racks (e.g. more than 75%) shall be equipped with a heat exchanger. The heat exchanger can thereby be integrated with the shelf or constitute a separate part in relation to the shelf, whereby in the latter case the heat exchanger is attached to the rack itself. The rack is equipped with two vertically running pipelines 15 and 16. The inlet connections to the heat exchangers' tubular coils are connected to the first pipeline 15, while the outlets from the heat exchangers' tubular coils are connected to the second pipeline 16. The pipelines 15 and 16 in the different racks are connected in parallel to a tubular evaporator or fluid cooler 17 of known type. In the fluid cooler, the tubular evaporator is indicated by 17a and the compressor by 17b. The compressor is connected to a condenser or water recoolor located outside of the premises via a line 17c for the refrigerant. In the case shown here, the tubular evaporator has been connected to the same condenser or water recoolor as the refrigerator module 7, but can otherwise be connected to a separate condenser or water recoolor. The piping system that includes the first and second pipelines 15 and 16 to the various racks is connected to the tubular evaporator's inlet 17a' and outlet 17a". The pipelines can also be connected in series, depending on the diameter of the tubing used. A pump 18 of known type is incorporated on the pressure side of the piping system. The fan's 7d outgoing air flow is kept to a temperature of about +8°C in order to minimize the water content of the supply air to about 6.5 grammes of water per kg of air. This is done in order to dry the air so that water does not condense on the outer surfaces of the heat exchangers. The air entering the air duct from the fan outlet can, owing to the ejector effect, entrain room air and thereby assume a temperature of +15—16°C.

The coolant in the piping system should preferably consist of freon in the liquid state, which is thus cooled in the fluid cooler 17 and circulated in the piping system by the pump 18. In the case illustrated here, the fluid has an inlet temperature at 17a' of up to +30°C, while its temperature at the outlet 17a" can be about +15°C. Circulation in the system is indicated by arrows 19 and 20.

The upward and preferably dry air streams 12a, 12b, 12c and 12d in the different racks thereby pass the heat exchangers' cooling flanges on the shelves equipped with heat exchangers, while

there is no undue mechanical weakening of the load-bearing capacity of the shelf, but rather the shelf can fulfil its load-bearing functions.

- According to the invention concept, the new apparatus shall be able to effect the cooling function essentially autonomously, i.e. without the aid of additional cooling equipment, for example in the form of row coolers, air conditioners and the like. It is, however, possible, if desired, to use the apparatus in combination with other cooling equipment, for example a row cooler.

- Through the invention, the rack or racks that make use of the new apparatus will, in one embodiment, function as a cooling buffer in the premises where the rack or racks are set up, while simultaneously cooling the telecommunications equipment in the rack or racks.

- In accordance with the concept of the invention, each shelf shall contain a horizontally extending cavity in which the heat exchanger for that shelf is mounted by means of a holding device. This holding device may take the form of a screen or grills running along the outer sides of the heat exchanger and be fastened along at least its long sides to the shelf. The shelf thereby consists of two essentially parallel load-bearing parts or beams, held together at their ends by side pieces and brackets, which can be of known type. The aforesaid cavity for the heat exchanger extends between the aforesaid parallel load-bearing parts. Cantilever supports also extend between the aforesaid load-bearing parts, and the middle sections of the cantilever supports extend over the aforesaid cavity. The cantilever supports in turn support the board magazines. The boards are placed on end in the board magazines and are enclosed entirely within the aforesaid board magazines. The board magazines are provided with through slots to permit air circulation past the sides of the boards and components. The board magazines incorporate a bottom part that supports the receptacles into which the boards can be inserted via matching plugs. The bottom part is also provided with through slots that permit air circulation.

- Metallic contact surfaces thereby exist between the shelf and the aforesaid holding device for the heat exchanger and between the shelf and the board magazines. The extended contact surfaces are situated on, *inter alia*, the aforesaid cantilever supports. In one embodiment, the extended contact surfaces also include long channels by means of which the holding device for the heat exchanger is clamped to the shelf. The board magazines, the cantilever supports, the holding device for the heat exchanger and/or the shelf itself can, in addition, be in direct contact, e.g. via metallic plates, with the cooling system's lines or coils, whereby direct contact is also obtained between the cold surfaces on the aforesaid lines and the unit in question.

- The above-described arrangement provides an effective indirect cooling function for the board components in the board magazines to

complement the cooling function that is obtained through natural convection and radiation from the heat exchanger.

- Through the proposed design principle, relatively large quantities of heat can be dissipated in this context by means of the heat exchanger and the appurtenant cooling equipment. Even if as large heat outputs as 10—15 Watts should be emitted from one or more boards in the board magazines, the design and operation of the heat exchangers and the appurtenant cooling equipment can be arranged to provide the necessary heat removal. The new arrangement can thereby effect removal of the heat developed in the racks without environmental nuisance, either by itself or in combination with supplementary cooling equipment, such as row coolers and air conditioners.

- Despite a high packing density, the highest temperatures of the boards need not exceed predetermined values, e.g. about 75°C. Obviously, the life of the various components is prolonged by reduced temperature, and it can be mentioned in this context that if desired, it is possible to operate the system so that the temperatures of most of the components will be around 65°C or lower.

- Despite the above-mentioned advantages obtained with the invention, the main advantage is that the shelf construction and the rack system as a whole need not be subject to any modifications, aside from provision of the cavity for the heat exchanger. The heat exchangers in the rack will therefore not occupy any extra space, but rather only such space as was previously not utilized in the racks of known design. The integration can be executed in such a manner that the load-bearing capacity of the shelf is not unduly affected.

#### Description of the Drawings

- A currently proposed embodiment of an apparatus that exhibits the significant characteristics of the invention will be described below with reference to appended drawings, where

- Figure 1 shows, in schematic form premises, for example at a telephone exchange, with racks containing telecommunications equipment that is cooled by the new apparatus, the latter comprising a combination of shelf coolers and row coolers.

- Figure 2 shows, in an end view, parts of a rack according to fig. 1.

- Figure 3 shows, in a horizontal view, a heat exchanger mounted in a shelf in the rack according to fig. 2.

- Figure 4 shows one embodiment of the heat exchanger and its mounting in a shelf in the rack.

- Figure 5 shows, in an end view, an alternative embodiment of the heat exchanger.

- Figure 6 shows a detailed view of a tube incorporated in the heat exchanger according to fig. 5 and cooling flanges arranged around this tube, with drop-collecting edges and drip tray

Figure 7 shows, in perspective viewed from in front and above, certain parts of a second

and extends over the greater part of their depth. Thus, the heat exchanger has a depth which is preferably 70—95% of the depth of the board magazines. In this manner, the heat exchanger can be made to act indirectly over the entire depth of the board. The temperature of the coolant entering the fluid cooler 117 can be up to about +30°C. The temperature of the outgoing coolant from the cooler can be down to +15°C.

- 10 The invention is not limited to the versions described above as examples, but can be subject to modifications within the framework of the following patent claims and invention concept. Values of temperature, cooling surface etc. can, for example, vary from one embodiment to another.

#### CLAIMS

1. Apparatus for cooling telecommunications equipment consisting of component-carrying printed circuit boards arranged in board magazines which in turn are mounted on shelves arranged on top of one another in a rack characterized in that one or more shelves are integrated each with its own heat exchanger which incorporate cooling flanges and at least one tubular coil which is connected via the heat exchanger to a cooler for a coolant running in the tubular coil; that each heat exchanger, viewed in the horizontal plane of its shelf, extends along the greater part of the shelf; that extensive heat-conducting metallic contact surfaces are arranged between each board magazine and the associated shelf as well as between the shelf and the heat exchanger; and that the aforesaid heat exchangers and cooler are arranged in such a manner that they contribute towards removing the heat given off by the telecommunications equipment by means of heat conduction via the aforesaid extensive contact surfaces, even at a high packing density of the aforesaid telecommunications equipment in the rack and a high rate of heat emission.
2. Apparatus according to claim 1, characterized in that half, and preferably the greater portion, of the rack's shelves are integrated each with its own heat exchanger, and that the heat exchanger's tubular coils are interconnected and connected to the cooler.
3. Apparatus according to Claim 2, in which the cooler is common to all heat exchangers.
4. Apparatus according to any of claims 1 to 3 characterized in that the heat exchangers and the cooler are arranged to ensure that the component temperatures for each card will not exceed about 75°C, preferably 65°C or lower.
5. Apparatus according to any of claims 1 to 4 characterized in that each heat exchanger has an effective cooling surface of up to 1.5 m<sup>2</sup>, preferably between 1.5 and 4 m<sup>2</sup>.
6. Apparatus according to one of the preceding claims, characterized in that each heat exchanger has a cooling capacity in excess of 150 Watts, preferably 500 Watts or higher.
7. Apparatus according to one of the preceding claims, characterized in that the rack(s), with its shelf-integrated heat exchangers, functions as a cooling buffer on the premises where the rack(s) is set up, while simultaneously bringing about cooling of the telecommunications equipment in the rack(s).
8. Apparatus according to one of the preceding claims, characterized in that it incorporates a cooling system, preferably open, arranged on the premises which in turn incorporates a compressed air source whose outgoing air flow is conducted in one or more air ducts underneath the rack(s) so that an upward air stream is created within each rack, where it passes different shelves arranged on top of each other with telecommunications equipment and from which it emerges at the top part of the rack into the atmosphere on the premises; that a heat exchanger with appurtenant cooling flanges and coolant-bearing tubular coil is mounted in each of at least most, e.g. 60—100%, of the rack's or racks' shelves that each heat exchanger extends over the greater part of the plane of the shelf that is perpendicular to the vertical direction of the rack; and that the aforesaid upward air stream in each rack passes the cooling flanges on the heat exchangers in the shelves provided with heat exchangers.
9. Apparatus according to one of the preceding claims, characterized in that each shelf is provided with a cavity extending in the horizontal plane, in which the heat exchanger belonging to that shelf is mounted by means of a holding device preferably consisting of a screen, which is connected to the body of the shelf via at least its two long sides.
10. Apparatus according to claim 9, characterized in that the shelf incorporates two essentially parallel load-bearing parts between which the aforesaid cavity extends; that cantilever supports are arranged to the load-bearing parts so that their middle sections extend across the cavity; that the cantilever supports carry on their middle sections one or more board magazines; that the extensive metallic contact surfaces include attachment surfaces between the holding device and the body of the shelf, between the cantilever supports and the body of the shelf and between the aforesaid middle sections and board magazines, providing for effective heat conduction between the interiors of the board magazines where the boards are placed on and the heat exchanger.
11. Apparatus according to one of the preceding claims, characterized in that metallic heat-conducting devices are connected between all or different units of the heat exchangers, the coolant lines, the board magazines, the shelves, the racks and/or the holding devices.
12. Apparatus according to one of the preceding claims, characterized in that the coolant circulated in the cooling system, preferably consisting of chlorofluorocarbon in liquid form, has a temperature entering the cooler of up to about +30°C and a temperature leaving the cooler of down to about +15°C.

incorporates two parallel load-bearing parts 127 and 128 (see also figure 9). Between these load-bearing parts, a cavity 129 is provided, as shown in figure 9. The heat exchanger 112' or 112" in question is mounted in this cavity. The heat exchanger is thereby mounted in a holding device, which preferably takes the form of a screen or grille 130 extending around the entire circumference of the heat exchanger. Along its long sides, the holding device 130 is provided with fastening pieces 130a and 130b, by means of which the holding device is fastened to the load-bearing parts 127 and 128. Thus, the fastening piece is fastened to the load-bearing part 127 by means of channels 131, which are screwed in place or otherwise fastened by means of screws 132 or the equivalent to the load-bearing part 127 so that an extensive contact surface is obtained between the fastening piece 130a and the load-bearing part 127. The aforesaid load-bearing part preferably consists of an extruded beam of aluminum or other metallic device. The fastening piece 130b is attached to the load-bearing part 128 by means of a long channel, which is attached to the load-bearing part 128 by means of screws 133 or equivalent fasteners, whereby the piece 130b is wedged between the clamping channel and the surface of the load-bearing part. The shelf is provided with bracket-shaped side pieces that incorporate projecting devices 134, 135, which are inserted in corresponding slots on the concerned rack post 105 and are designed in such a manner that, after being inserted in the slot, they lock to the post to provide appropriate support for the shelf with appurtenant heat exchanger, board magazines and boards.

The design of the cantilever support (see also figure 7) is shown in greater detail by figure 8. The cantilever support has a middle section 123a that reaches across the aforesaid cavity between the load-bearing parts 127 and 128 of the shelf. The cantilever support is anchored at its ends 123b and 123c to the load-bearing parts 127 and 128. The contact surfaces between the aforesaid free ends 123b and 123c on the one hand and the load-bearing parts 127 and 128 on the other hand are also extensive. The board magazines 110 are placed on the aforesaid cantilever supports 123a, whose top surfaces 123c' have been made extensive in the horizontal plane. The board magazines have a back piece, to which box-shaped or cassette-shaped pieces are applied, in which the circuit boards are placed on end.

Receptacles in which the boards can be connected via matching plugs are provided on the front side of the back piece. The box-shaped part on the board magazine is connected via its back surface 110a to the device 125, which thereby extends along a large part of the height of the board magazine.

The aforesaid back piece and board magazine boxes are made with slits and/or cutouts so that free air circulation is obtained between the circuit boards placed on end in the board magazines with

their components. The convection that is brought about owing to, inter alia, the cold surfaces of the heat exchangers and the hot components gives rise to air currents past the components on the

boards and removal of the heat generated in the components by the air currents. Such air currents between the boards in the board magazines are indicated in figure 8 by first arrows 136, which symbolize the upward air currents. Second arrows 137 symbolize downward air currents, while third arrows 138 symbolize circulating air currents between the boards. In addition, heat dissipation is obtained by direct radiation from the hot board surfaces onto the heat exchangers 112' and 112".

The aforesaid extensive metallic contact surfaces contribute appreciably to heat transport from the boards/magazines to the colder surfaces on the heat exchangers.

The heat exchangers in a rack are thereby designed with such large effective cooling surfaces that cooling capacities in excess of 150 Watts are obtained from the heat exchangers. It can hereby be mentioned that cooling capacities of 500 Watts or higher from each heat exchanger are within the realm of possibility. Thanks to the specific integration between each shelf and its heat exchanger, a large effective cooling surface can be obtained in the shelf, 1.5—4 m<sup>2</sup> can be mentioned as an example of the size of an effective cooling surface.

The integrated cooling function with heat conduction via the contact surface, radiation and natural convection can be provided with the proposed principle in such a manner that, despite a high packing density of the boards and their components, the maximum component temperature on each board can be limited to about 75°C. In one proposed embodiment, however, it is proposed that the heat exchangers be arranged and operated in such a manner that maximum component temperatures of about 65°C or lower are obtained.

Figure 9 shows, inter alia, the connection of the devices 124 and 125 to the coolant lines 113 and 114. The devices 124 are connected via extensive contact surfaces 124a to the rack posts 105 and 105'. The side pieces on the shelf are indicated by 139 and 140 and the cavity between the load-bearing parts 127 and 128 is indicated by 141.

The rack has a chimney-like duct 142 at the back, which contains the aforesaid lines 113 and 114 and the connections 112a, 112b on the heat exchangers (see also fig. 10). The figure is simplified in that the link between the connections 112, 112a, 112b and the vertical pipes 113 and 114 are symbolized by thin solid lines 143 and 144. The board magazines are shown schematically, since they are assumed to be of known type.

Figure 10 shows the extent of the heat exchanger in the horizontal plane of the shelf and its mounting in the cavity 141. The heat exchanger occupies a large part of the shelf's horizontal plane, for example 60—90%. The heat exchanger runs underneath the board magazines

13. Apparatus according to one of claims 8—12 characterized in that the aforesaid compressed air source or fan for generation of the aforesaid upward air stream in the rack(s) and the  
5 air circulation on the premises is incorporated in a refrigeration module of known type that preferably operates by direct expansion, which refrigeration module incorporates a cooling coil compressor(s)  
10 a fan and preferably a filter in addition to which a condenser or water recoler belonging to the refrigeration module is located outside the premises.

14. Apparatus according to claim 13, characterized in that the refrigeration module is  
15 arranged to create forced upward air streams in each rack, bringing about a cooling capacity of 150 Watts or higher from the heat exchanger on each shelf.

15. Apparatus according to one of the  
20 preceding claims, characterized in that the shelves on the racks are arranged to carry, in addition to various telecommunications units the aforesaid magazines with boards with printed wiring and telecommunications components; that the upward  
25 air streams pass upwards between the boards and are directed out into a chimney duct via the rear of the rack; and that the heat exchangers extend from the rear of the rack in the direction towards the front of the rack in such a manner that they  
30 occupy preferably about 2/3 of the shelf's depth, providing favourable cooling of and at the rear portions of the rack as well.

16. Apparatus for cooling telecommunications equipment substantially as hereinbefore described  
35 with reference to and as shown in the accompanying drawings.